

# WRF-BEP/BEM simulation over Barcelona with local climate zones



**I. Ribeiro**, M. Falls, A. Zonato, G.Villalba, A.Martilli

HARMO'19, 06.06.2019 – Bruges

Quantify the impacts of **greening the city** on:

**Air quality**

**Urban heat island, thermal comfort**

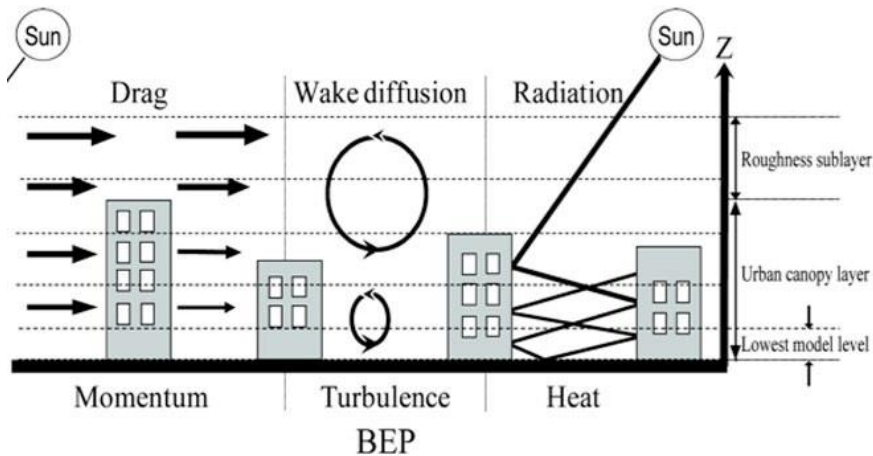
**Urban modelling**

adequate tools, high resolved, detailed input data

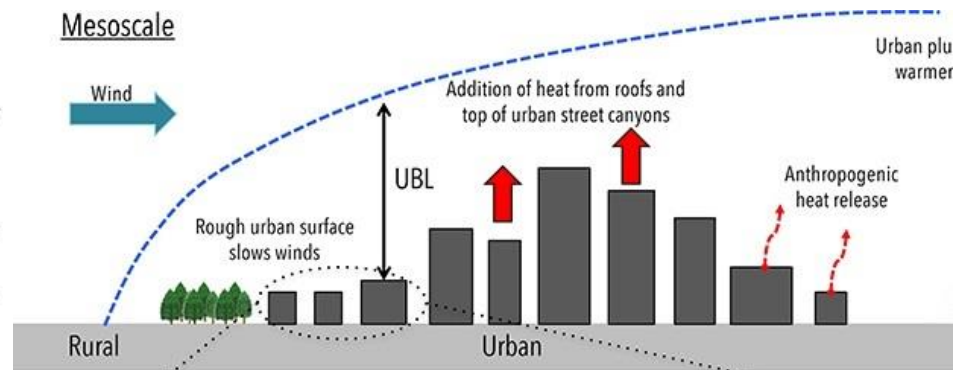
# Urban schemes in WRF

Urban schemes compute the thermal and momentum interactions between the atmosphere and the city

**Building Effect Parameterization (BEP):**  
a multi-layer layer scheme



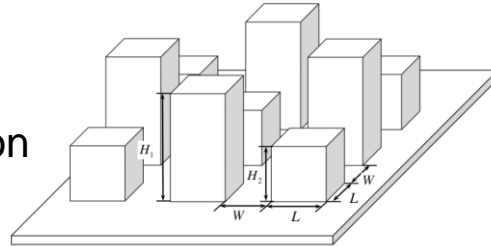
**BEP + Building Energy Model (BEP+BEM):** 2<sup>nd</sup> generation BEP considering heating/cooling in buildings



Need additional urban parameters and high resolved input data/simulation

## Geometry

Building height and width  
Street width and orientation



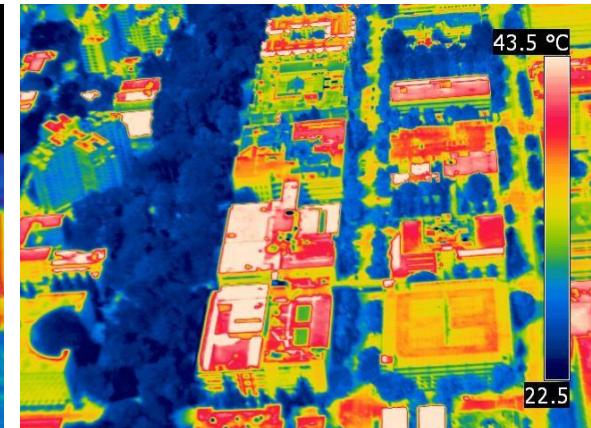
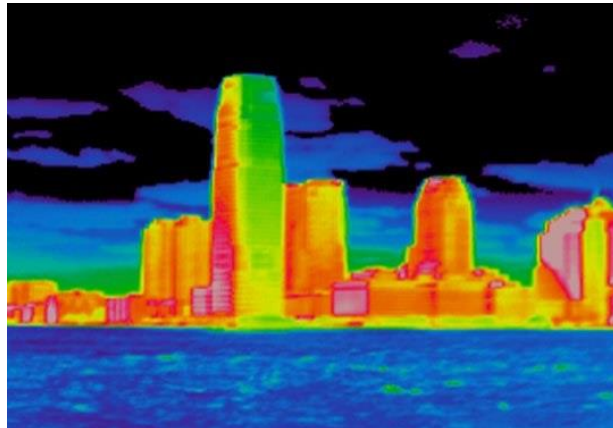
## Building energy related (BEM)

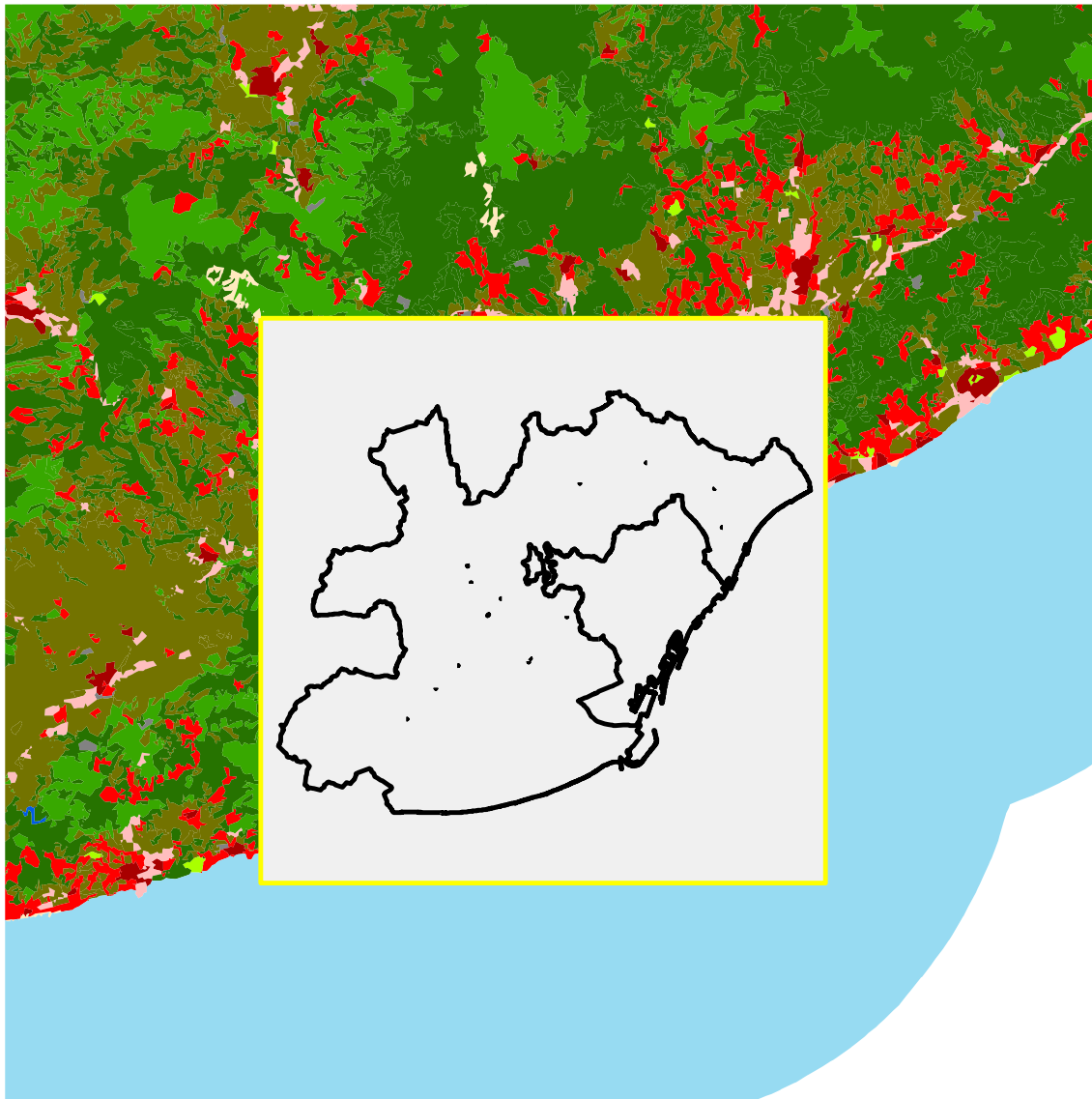
Target T and RH (A/C)  
A/C daily profile  
Thermal efficiency  
ratio windows/wall  
...



## Physic characteristics of surfaces (ground, walls and roofs)

Albedo  
Heat capacity  
Emissivity  
Thermal conductivity

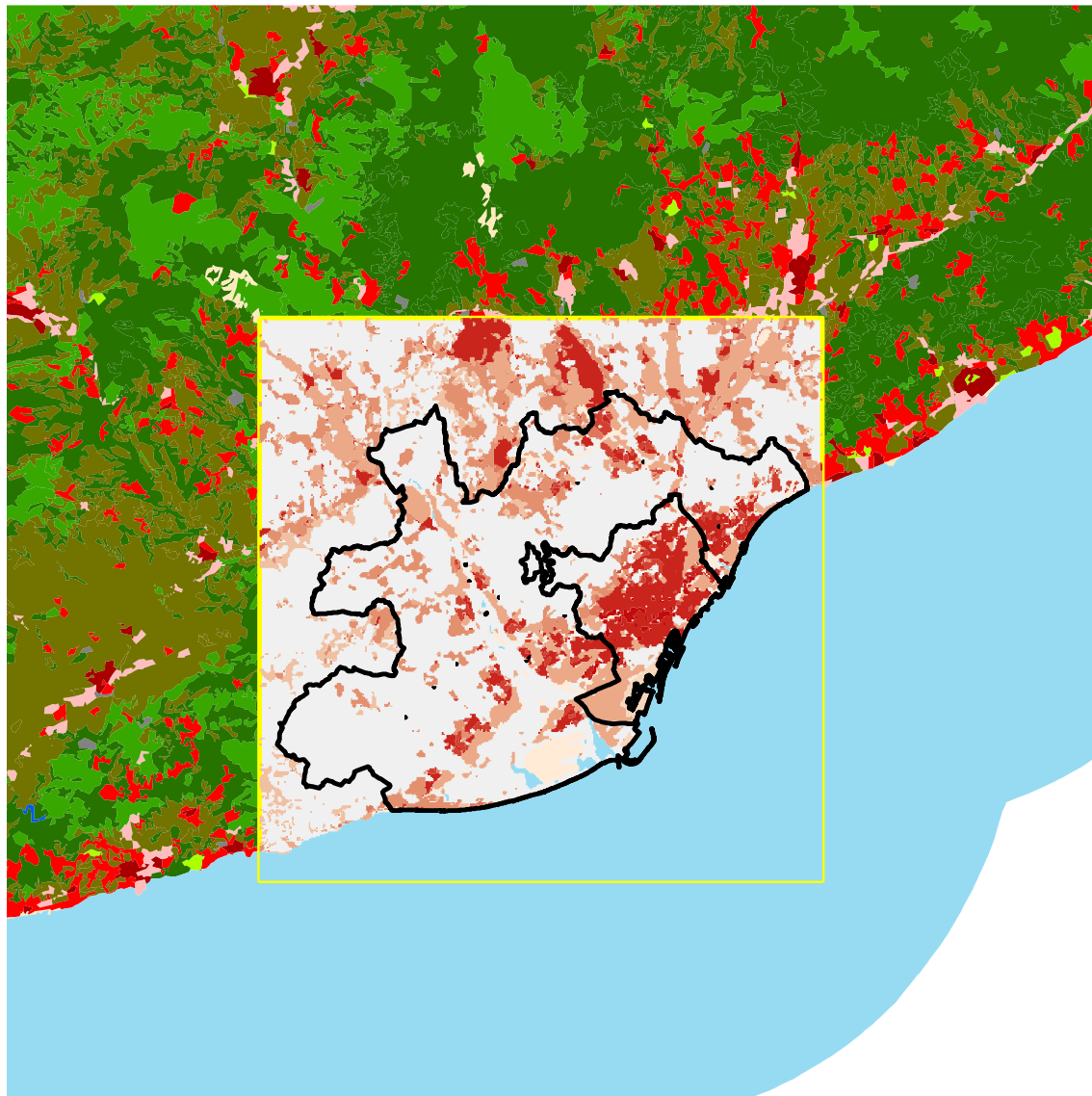




Corine Land Cover 2012

### 3 urban classes

continuous urban fabric  
discontinuous urban fabric  
commercial / industrial



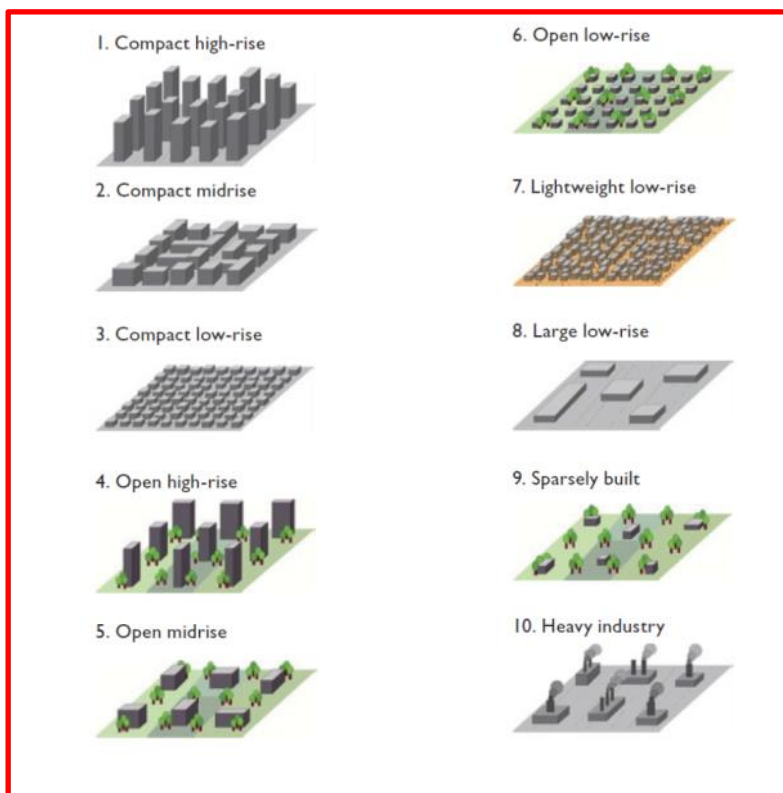
CLC12  
+  
Local Climate Zones

~~3 urban classes~~

11 urban classes

- LCZ result from the World Urban Database Access Portal Tool (**WUDAPT**)
- Based on Urban Atlas, 3D ortophotos, images from Landsat 8,7 and Sentinel 2)
- It classifies urban and rural lands with **similar thermal characteristics, form and function.**

## Urban classes



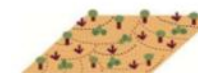
A. Dense trees



B. Scattered trees



C. Bush, scrub



D. Low plants



E. Bare rock or paved



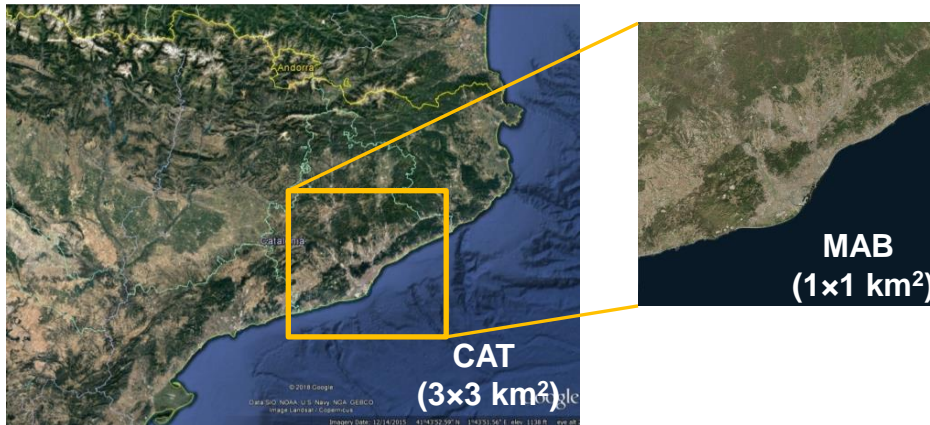
F. Bare soil or sand



G. Water



WRFv3.9 adapted according to Brousse et al. (2016) and Martilli et al. (2016) for the new land use information and classes (LCZ)



July 2016

CAT (NS;WE): (270;278)km  
MAB (NS;WE): (78;78)km

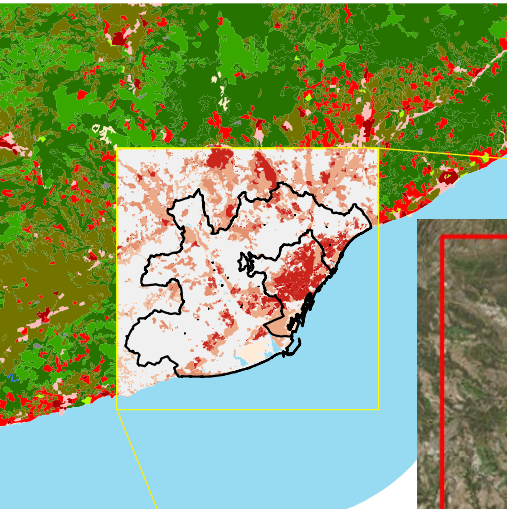
- **Vertical layers:** 45 layers up to ~16 km (1<sup>st</sup> - 5<sup>th</sup> layers: 10m thickness )
- **Noah Land Surface Model**
- **Bougeault-Lacarrère (Boulac) PBL scheme**, designed for BEP

## Simulations

- **BULK:** included in the Noah LSM. No distinction of urban land uses
- **BEP:** specific urban parameters (geometry and physic/thermal characteristics)
- **BEP+BEM:** considers energy balance of building heating and cooling



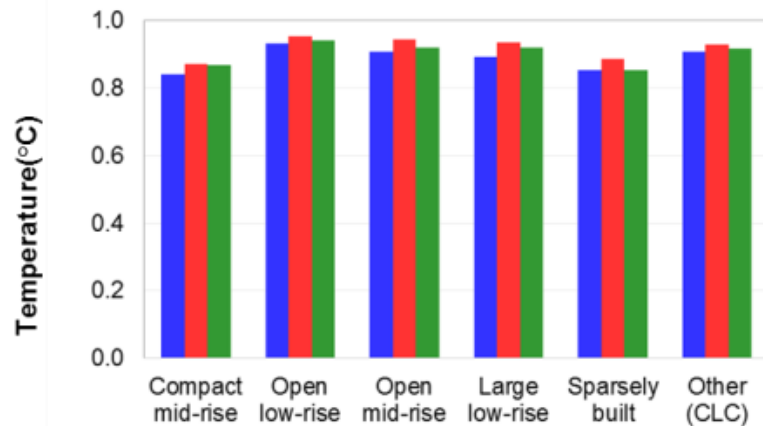
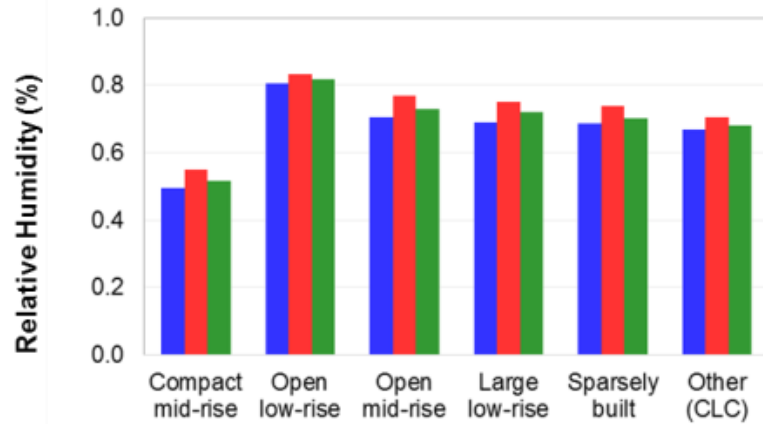
# Observations



## Meteo stations LCZ class

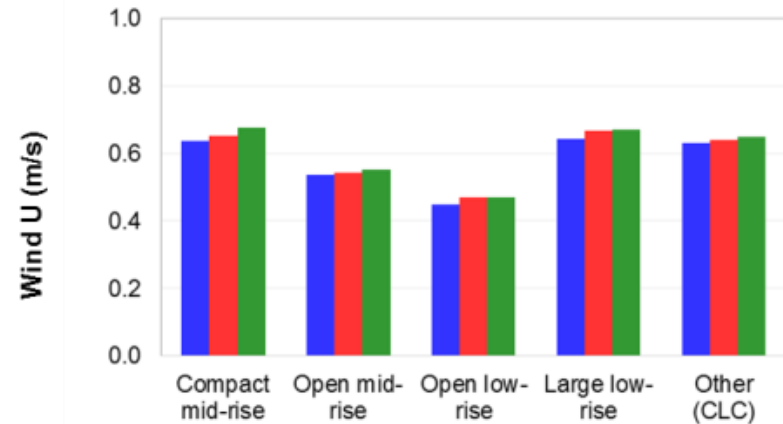
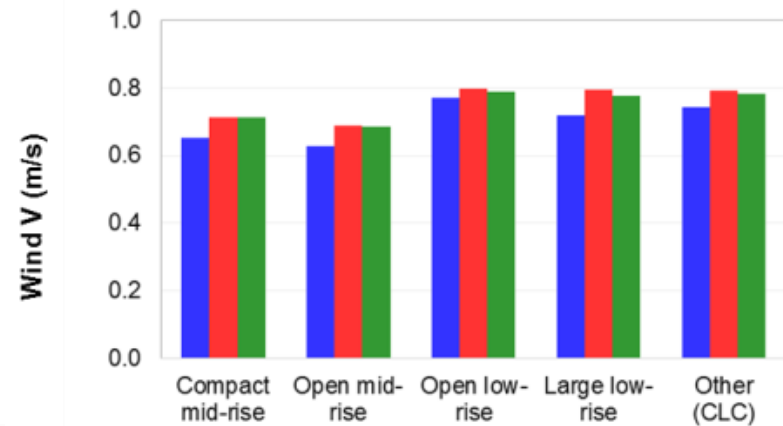
- Compact midrise
- Large low-rise
- Open low-rise
- Open midrise
- Sparsely built
- ▲ Water
- ▲ Cropland/nat vegetation
- ▲ Croplands
- ▲ Evergreen N Forest
- ▲ Open Shrublands
- Radiosonde
- MAB, city limits
- LCZ\_limits

## Correlation coefficient - R



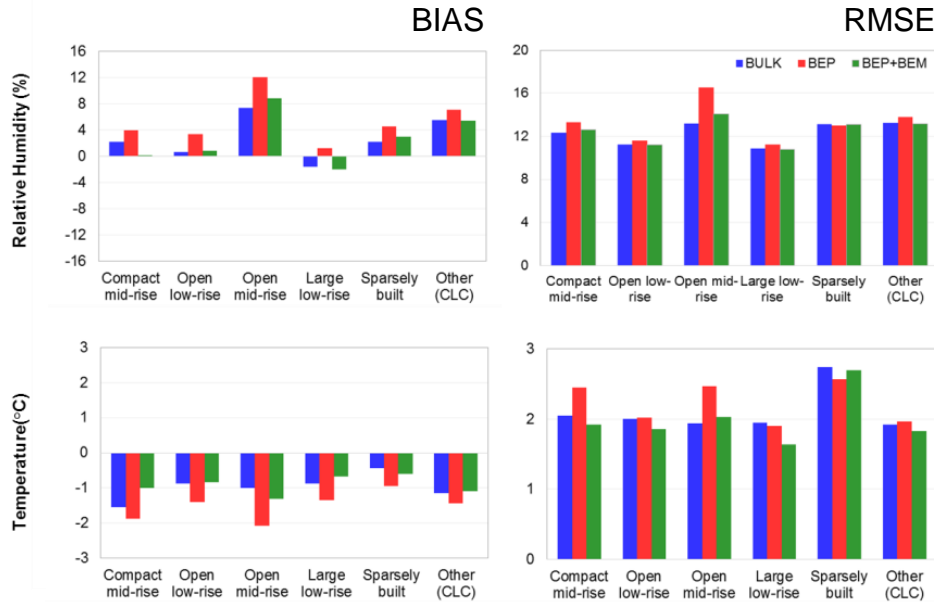
- Urban schemes improved R regardless of the land use class

■ BULK ■ BEP ■ BEP+BEM



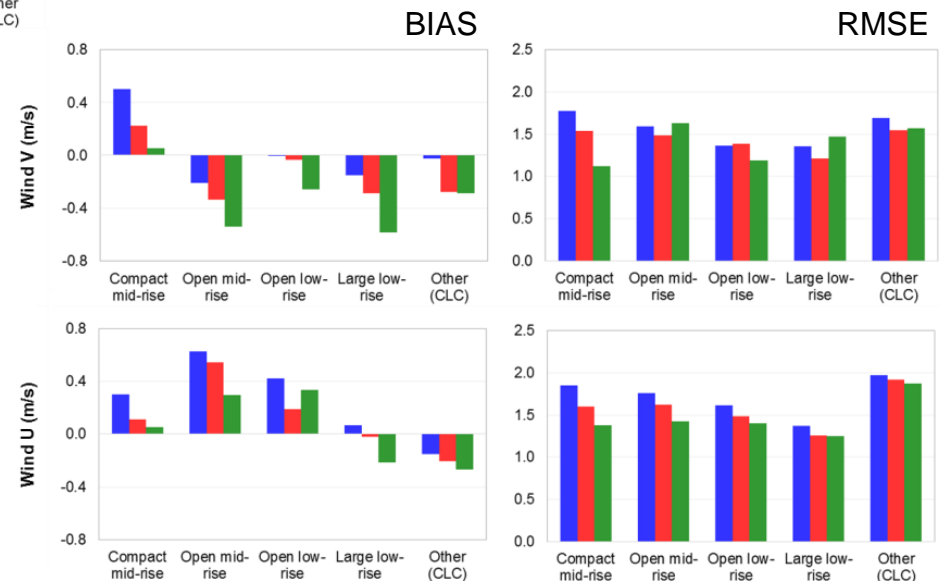
- BEP with the largest R

## Errors: BIAS and RMSE



- BIAS >0 : RH, wind V
- BIAS <0 : T, wind U

- Larger error values for BEP
- BEP+BEM with the lowest BIAS and RMSE in most of the LU classes, specially for wind

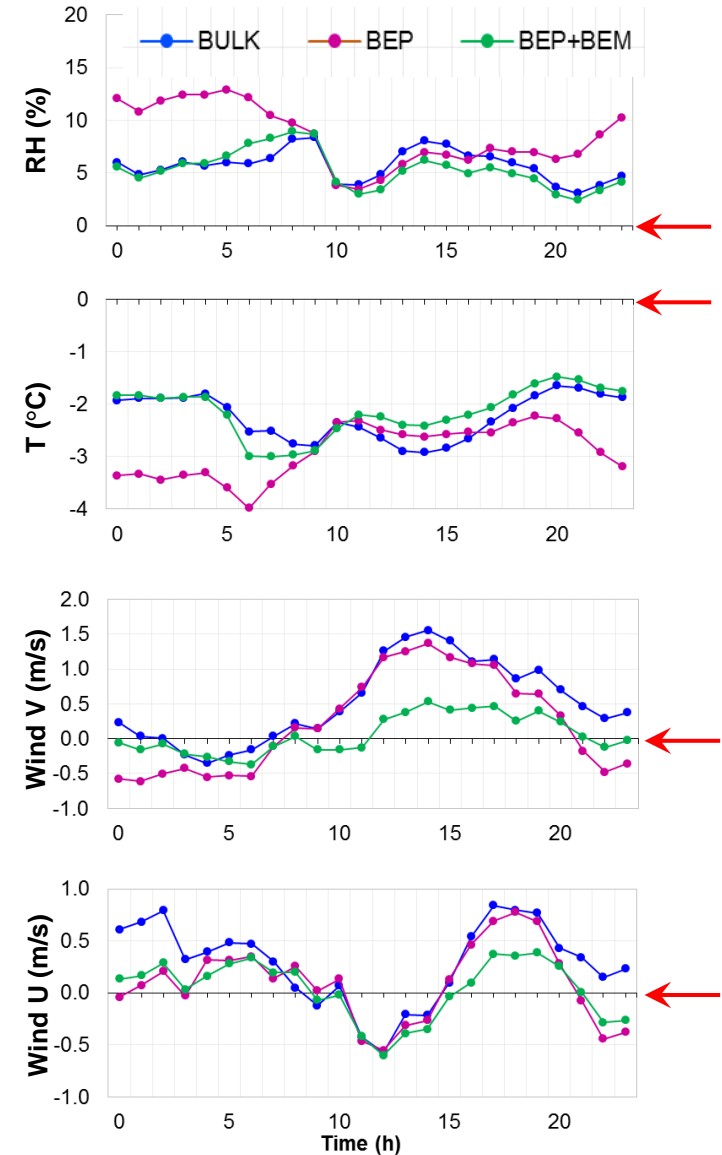


# Results

## BIAS daily profile – Raval

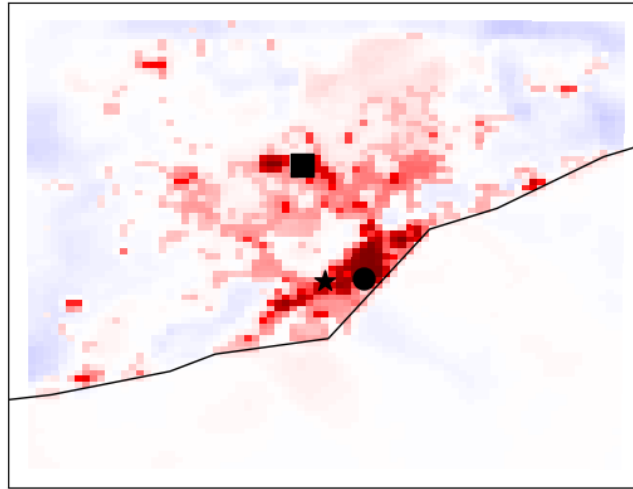


- BEP: colder (-4°C) and more humid (+13%) in the night
- BEP+BEM: similar to BULK (T and RH), better during light time  
 Wind: similar to BEP or better – Improves during day light (V) or in the afternoon (U)

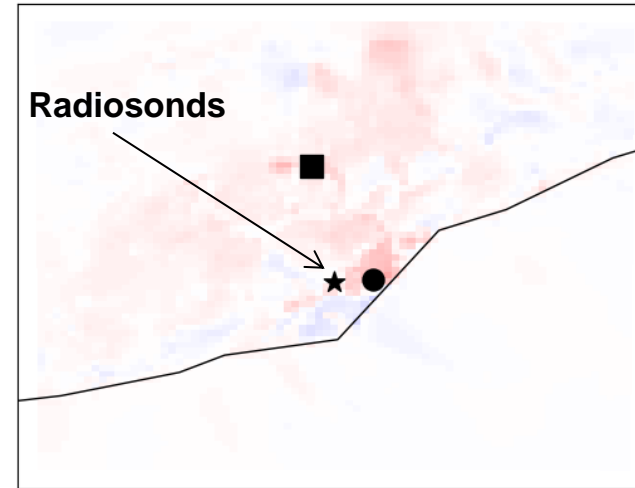


## PBLH

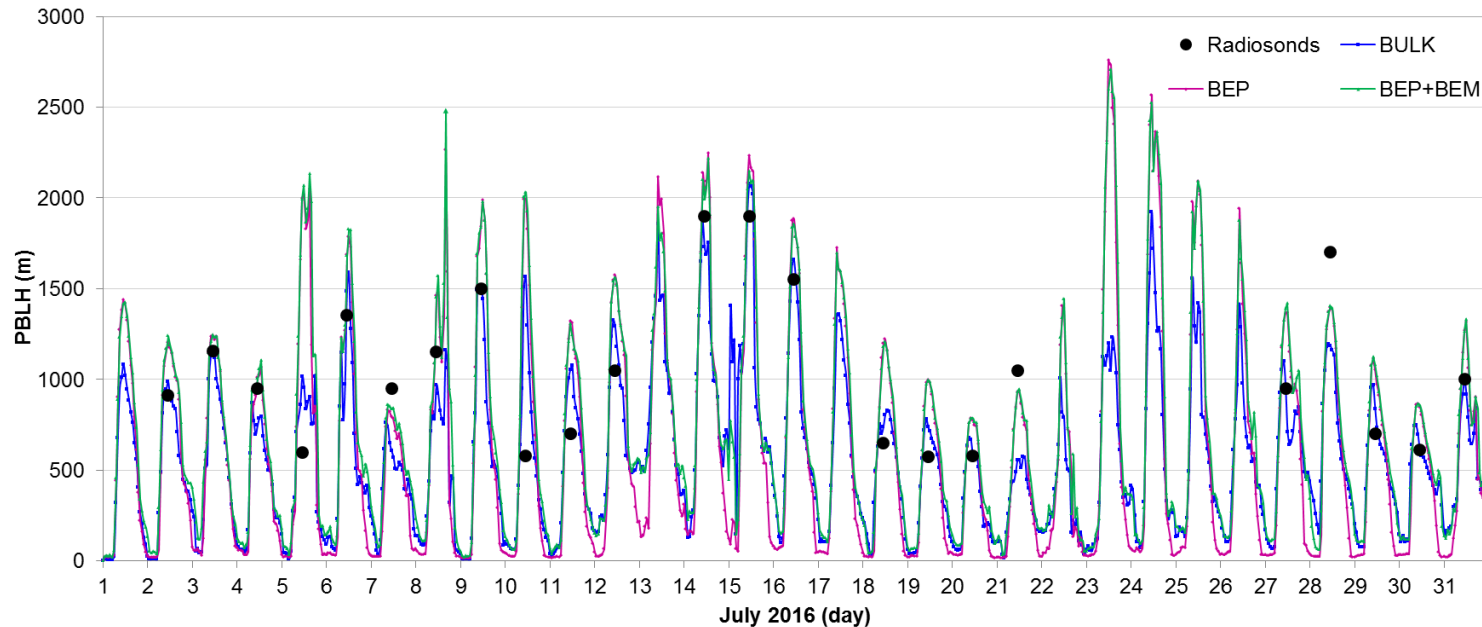
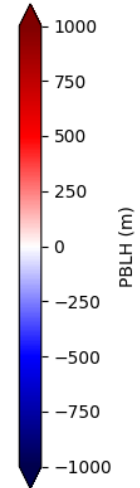
### BEP+BEM - BULK



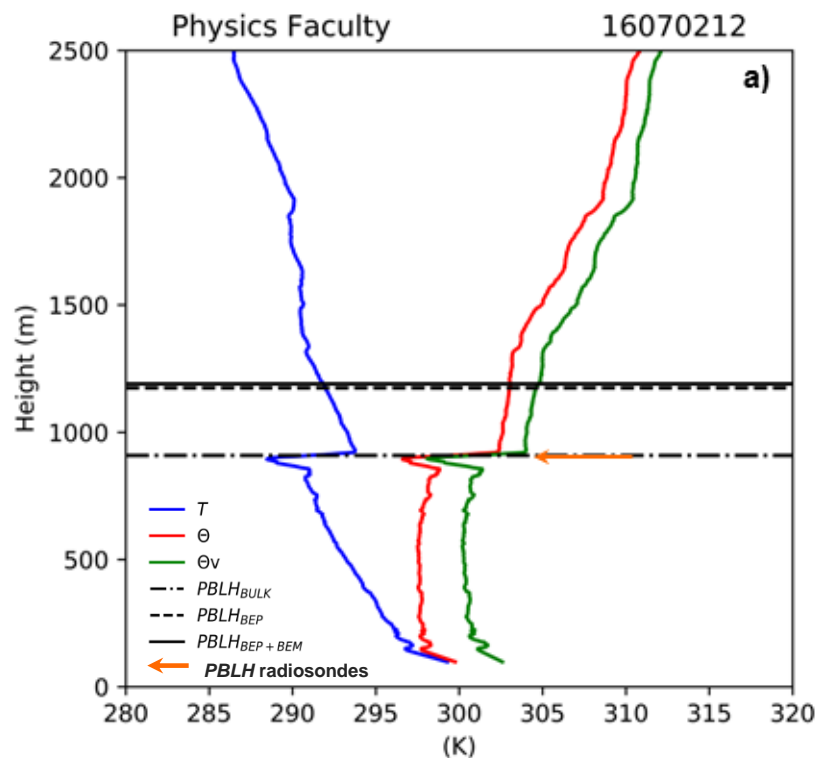
### BEP+BEM - BEP



### 12h



## PBLH



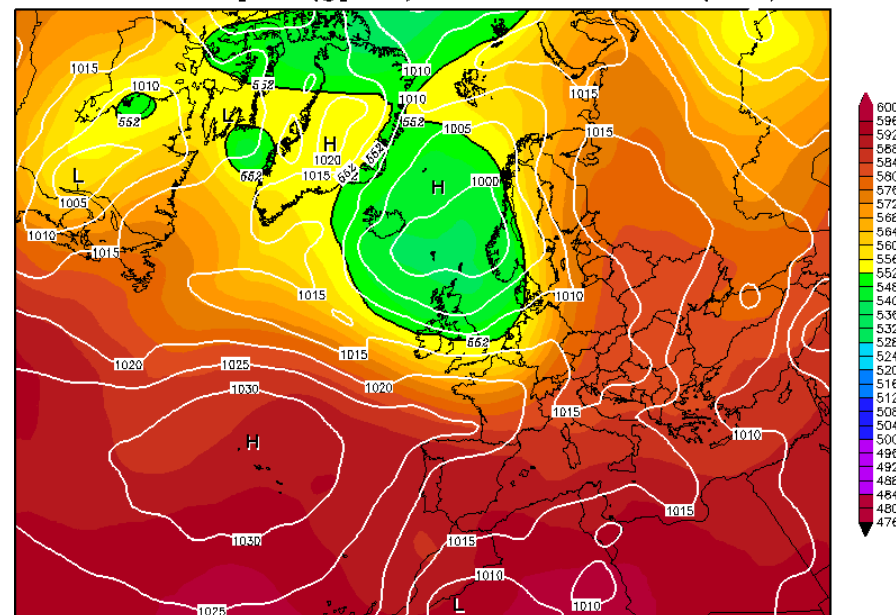
**Bias [model – observations] (m)**

**BULK** 74

**BEP<sub>def</sub>** 289

**BEP+BEM<sub>def</sub>** 326

Sat,02JUL2016 12Z  
500 hPa Geopot. (gpm) und Bodendruck (hPa)



Data: CFS reanalysis 0.500°  
(C) Wetterzentrale  
www.wetterzentrale.de

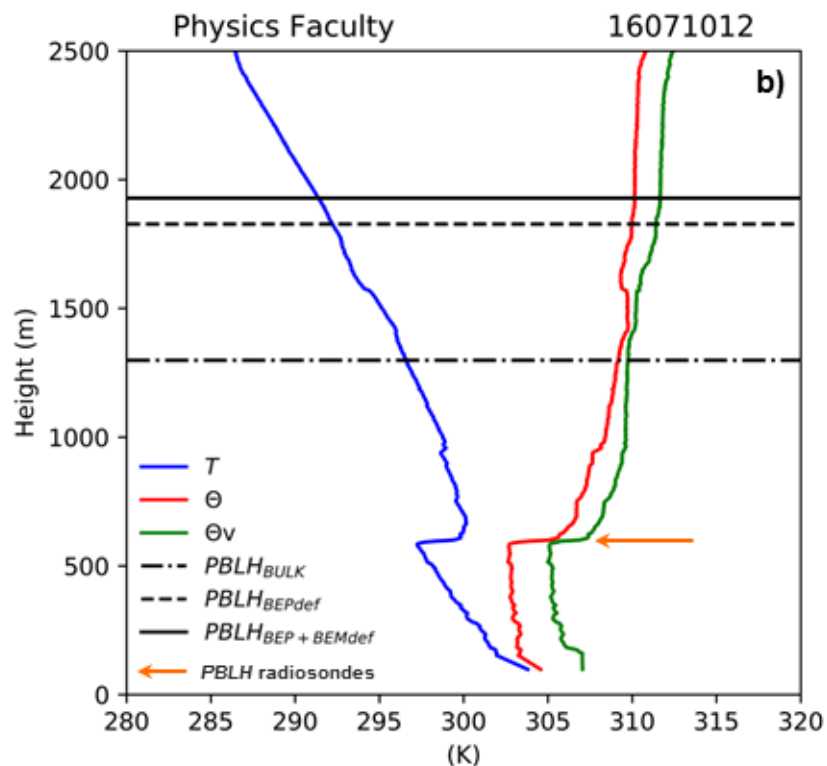
Most common synoptic condition in summer.

**H** over Azores.

**L** over Scandinavia.

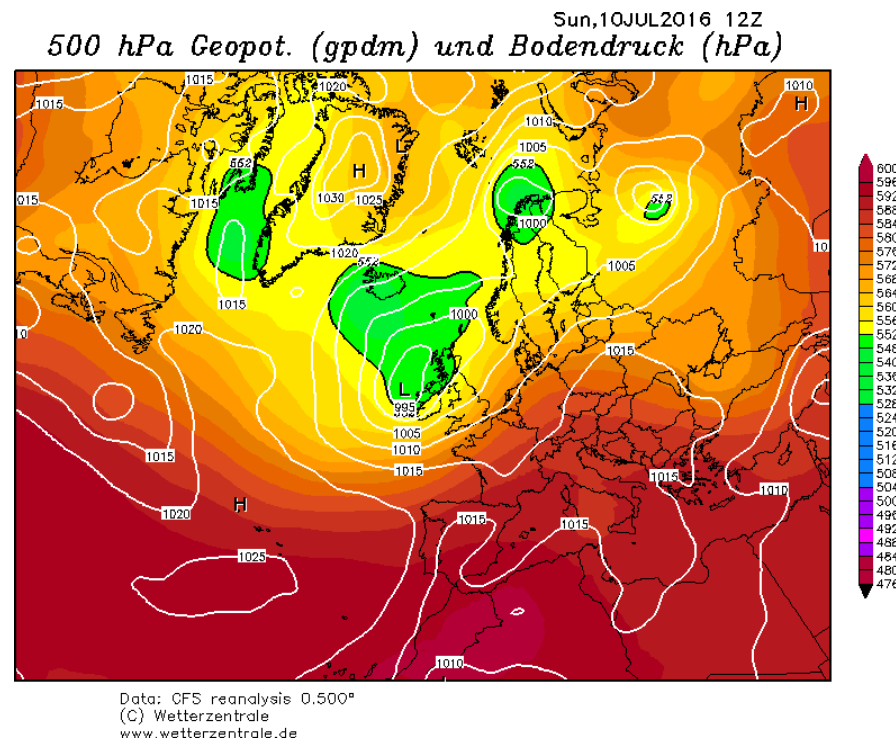
Both urban schemes overpredict the PBLH, which may be related to a higher buoyancy production than BULK.

## PBLH



### Bias [model – obs] (m)

BULK	987
BEP	1411
BEP+BEM	1451

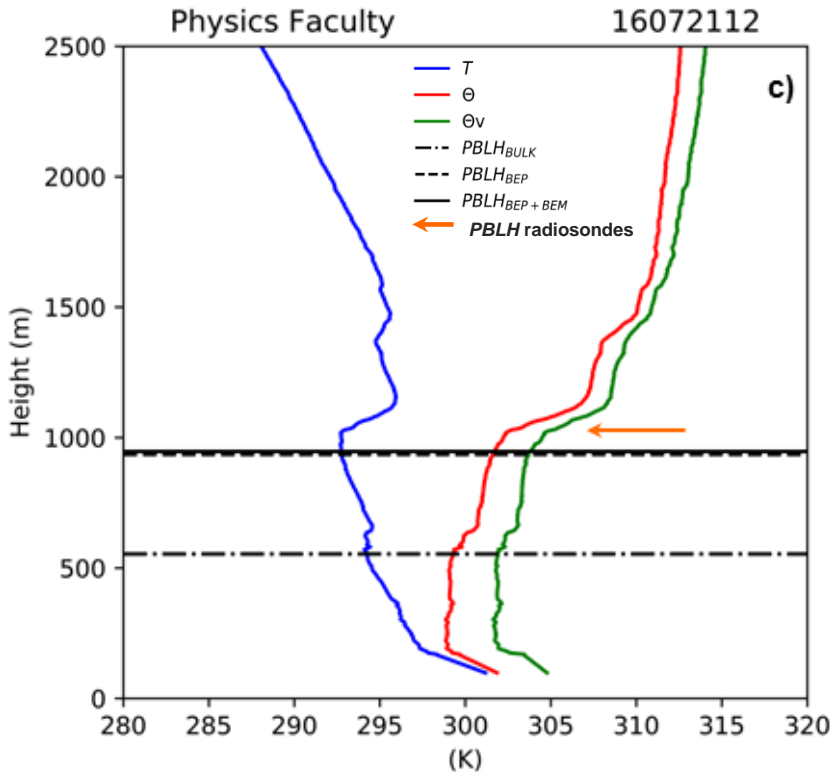


**H** is over the Azores islands.

**Anticyclone ridge** over the IP – atmosphere highly stable above the PBL.

**Low thermal** system boosted by solar radiation in the IP - not strong enough to be expressed in altitude (overestimated by models).

## PBLH

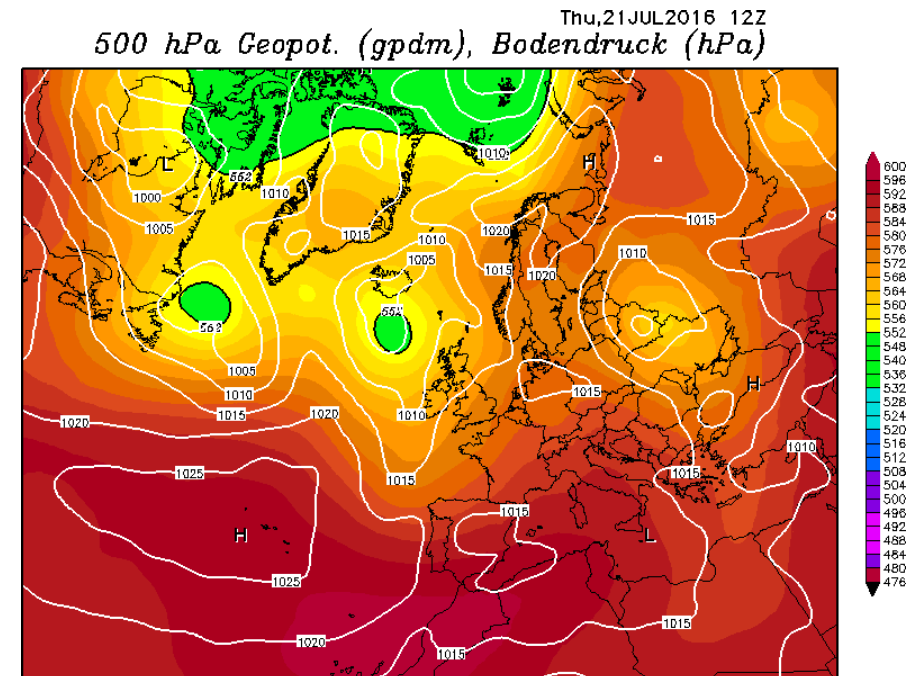


Bias [model – obs] (m)

**BULK** -494

**BEP** -119


**BEP+BEM** -116



Data: CFS reanalysis 0.500°  
(C) Wetterzentrale  
www.wetterzentrale.de

18-20/7: **L** over Atlantic invades southwards to IP provoking North Atlantic advection to W of IP, bringing saturated air.  
On 21<sup>st</sup>, the **L** dissipates and the moisture air warms up leading to atmospheric unstable conditions. WRF underpredicted PBLH.  
Urban schemes with better performance due to their overprediction trend.



- BEP+BEM presents the best performance for RH, T and Wind
  - Urban schemes cause problems on PBLH prediction?
  - The use of LCZ provides more detailed information to the model - city morphology and physic properties of surfaces (good database for urban climate and air quality simulation).
  - Input data on urban parameters must be improved – gridded instead of table
- 
- There is room to increase the horizontal resolution

# Thank you!

[Isabel.ribeiro@smhi.se](mailto:Isabel.ribeiro@smhi.se)

